ADVANCED ACCELERATOR APPLICATIONS

Technical Quarterly Review

(January-June 2002)

WBS 1.03 - Systems Technologies - ANL

TREAT Experiments - Engineering Feasibility

Sodium-Cooled ADS Reference Design

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Washington, D.C., July 10, 2002

ANL Activities - FY '02

- ADTF Documentation - J. Herceg
- TREACS - Feasibility Study - G. Palmiotti
  - Coordination with
    - ANL-W
    - Idaho Accelerator Center (ISU)
- ADS Reference Design - J. Herceg
  - Coordination with
    - LANL (Sodium-cooled/LBE-cooled ADS)
    - BNL (physics)
    - B&R (facility layout)

ACCOMPLISHMENTS (Jan - Jun '02)

- Issued ADTF System Design Description and associated documentation
- TREACS - Feasibility Study underway
  - Experiment layout
  - Target design
  - Issued report to DOE on TREACS (technical and cost estimates)
- ADS Reference Design
  - Developed scaled-up LBE target; issued document
  - Developed preliminary facility requirements; issued documentation
  - Continued scaled-up engineering design of sodium-cooled ADS facility

TREACS
(TREAT Experiment for Accelerator-Driven System)

- Purpose: Experimental validation of dynamic behavior of coupled accelerator-multiplier system
  - Support development of control mechanisms and control strategies for an ADS system
  - Support TRADE program (licensing basis support,…)

TREACS - Feasibility Study

- Assessment of the engineering feasibility of the experiment
  - Facility layout - test assembly
  - Target design
  - Target cooling
  - Safety
  - Physics

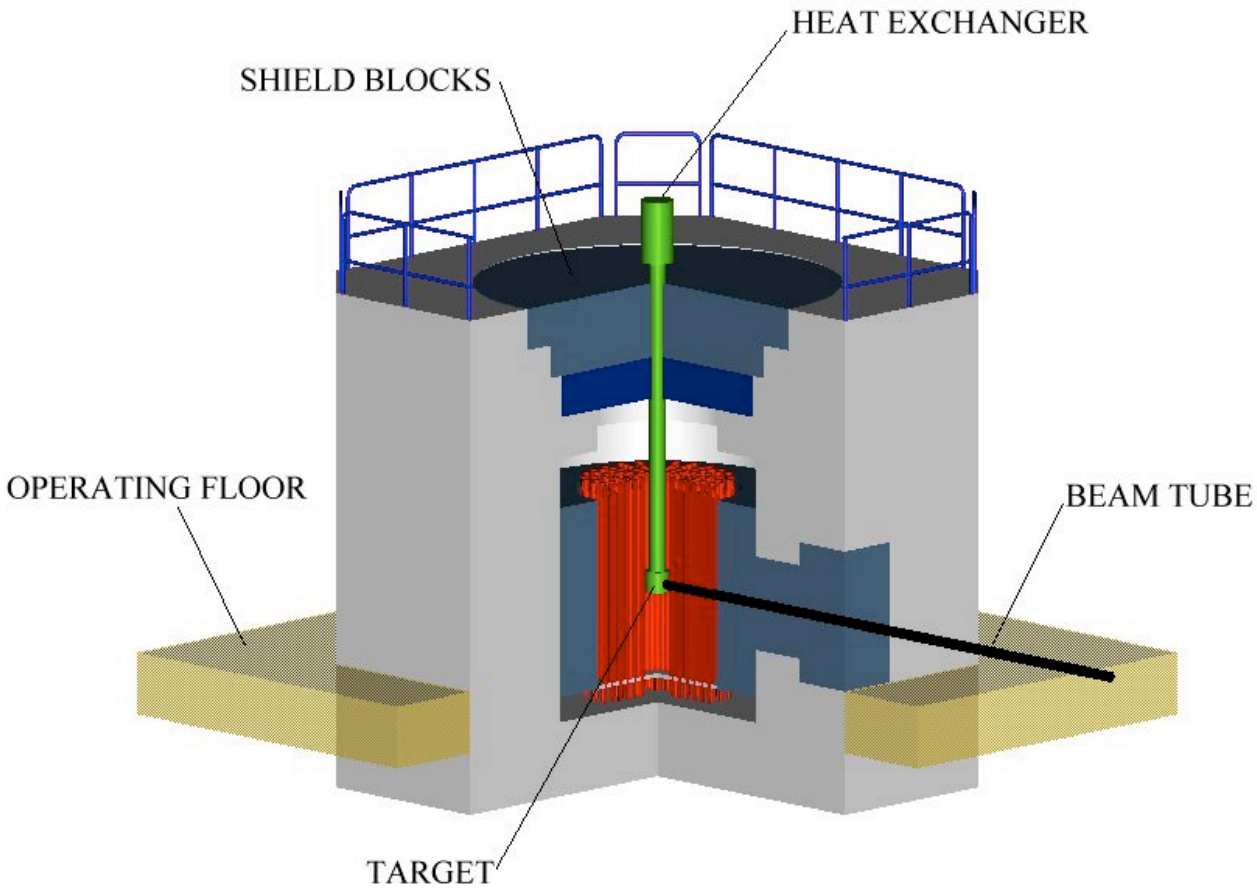
TREACS

- Study the start-up and shutdown procedures for an ADS; validation of the instrumentation needed for monitoring such a procedure.
- Study the domain of reliable operation of an ADS system at different levels of subcriticality (from source-dominated to critical).
- Simulate different phases of fuel irradiation (burn-up swings) by control rod movements.
- Validate different techniques for subcriticality measurement in a system at substantial power.
- Study the correlation between reactor power and beam current.

TREACS - Engineering Feasibility

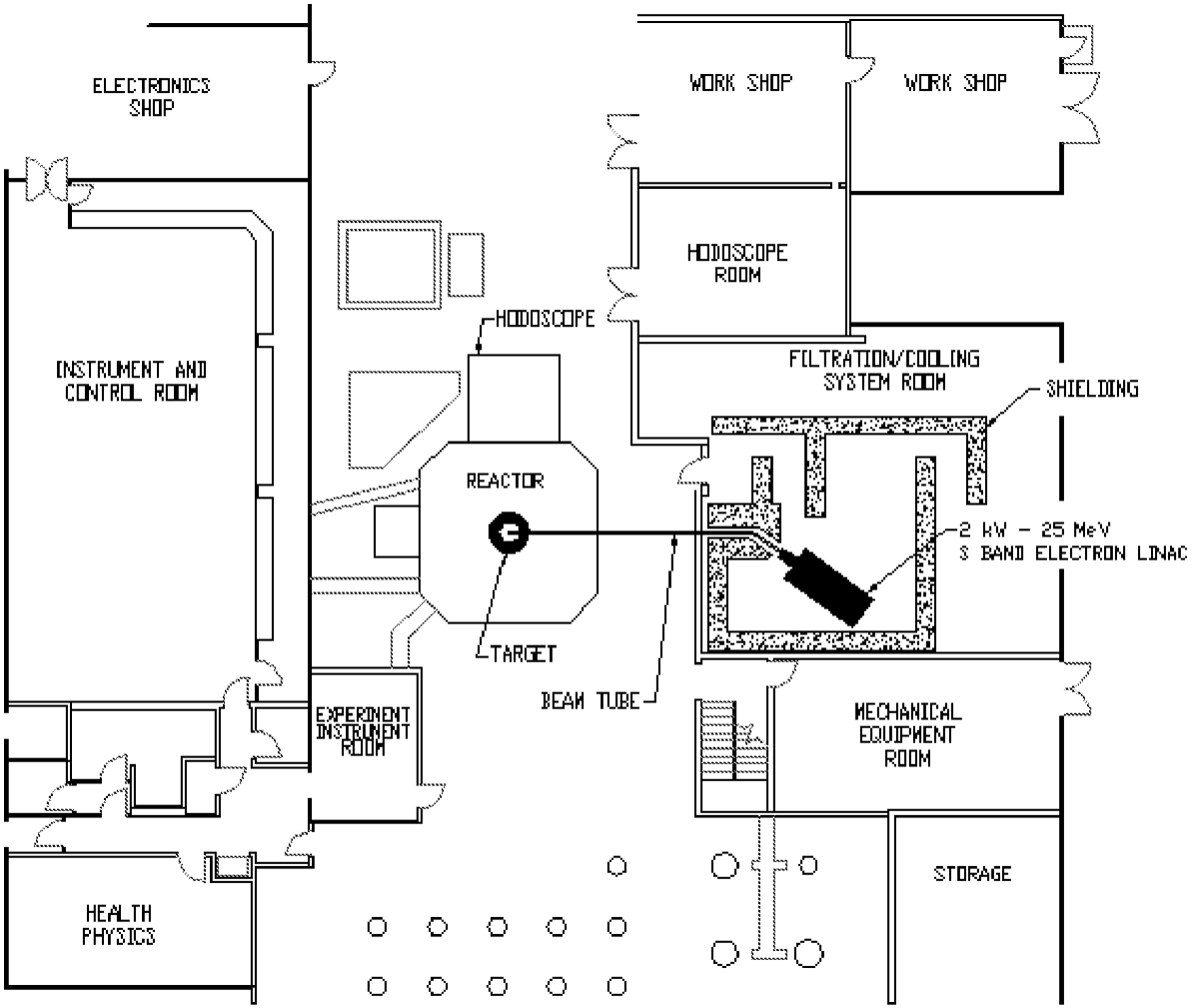
- Use of Idaho Accelerator Center (IAC) electron accelerator - 30 Mev LINAC
- A source strength of about 10^{14} n/sec
- U target (EBR-II blanket material)
- Target assembly inserted from the top
- Electron beam inserted horizontally

TREACS - Layout



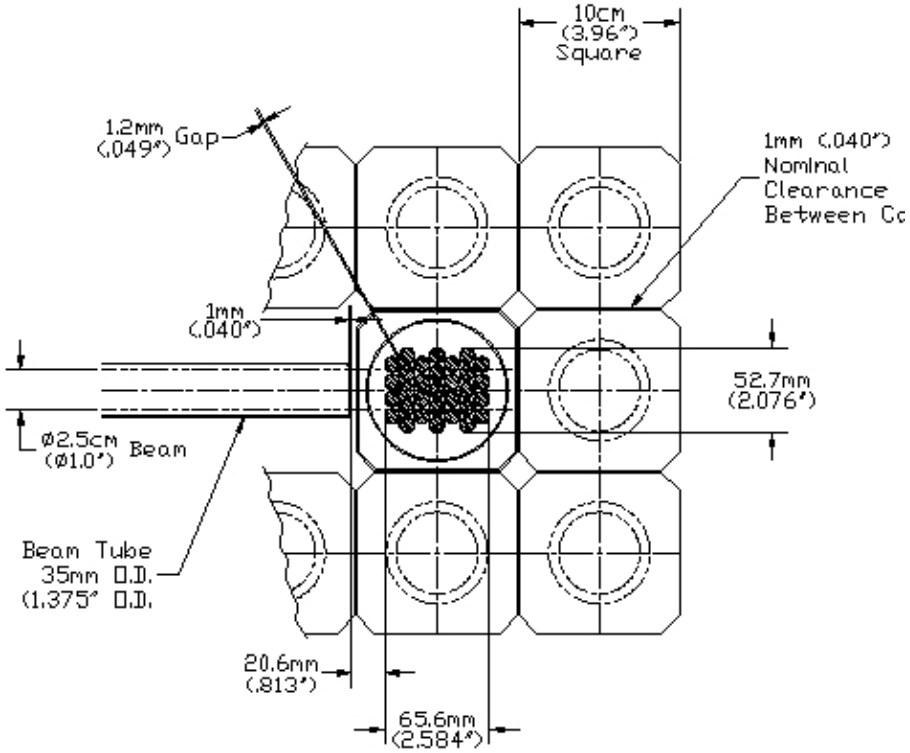
TREAT REACTOR

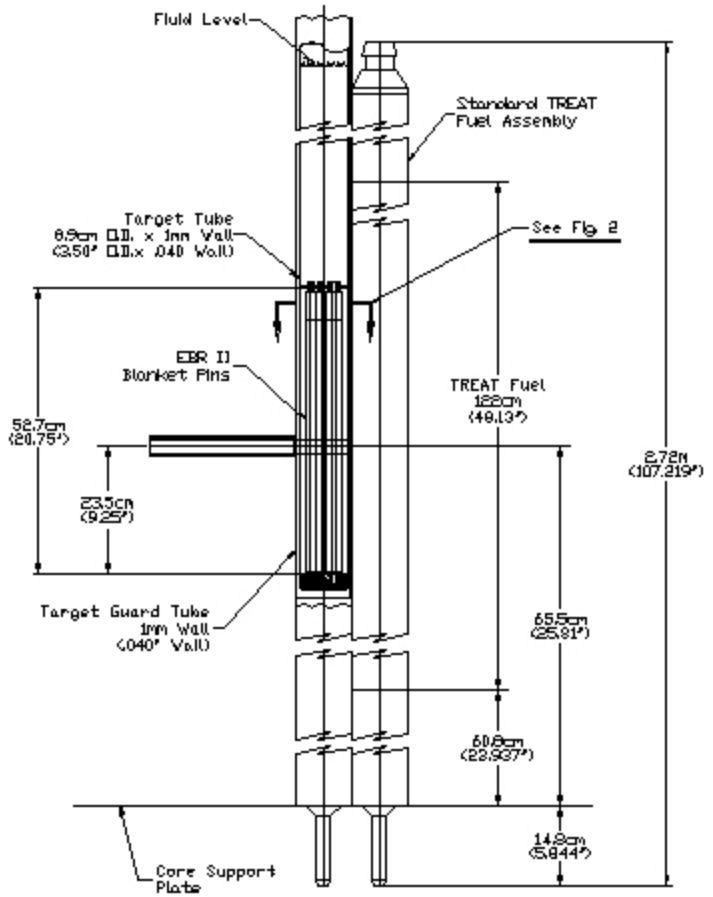
TREACS - Layout



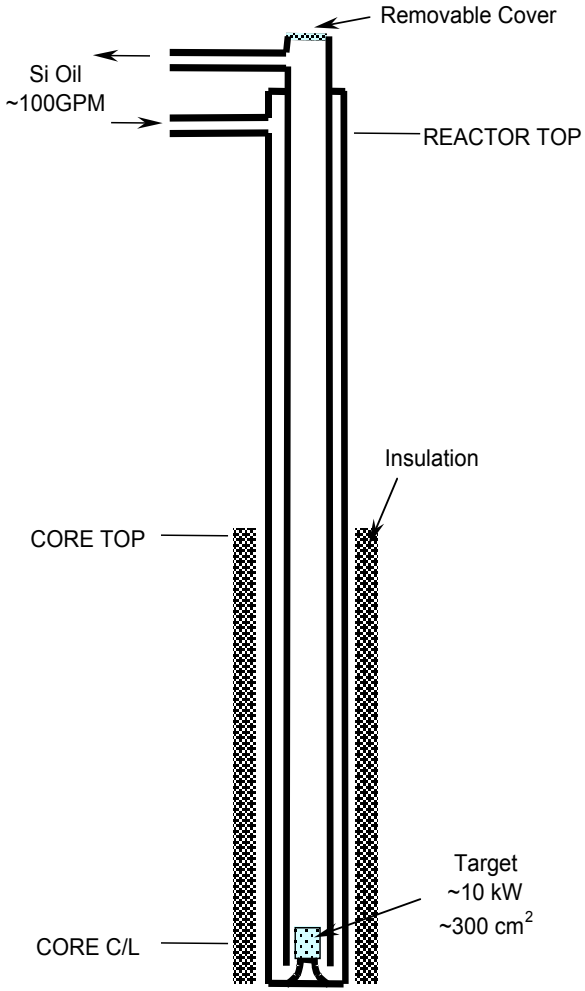
TREAT REACTOR BUILDING SOUTH HIGH BAY

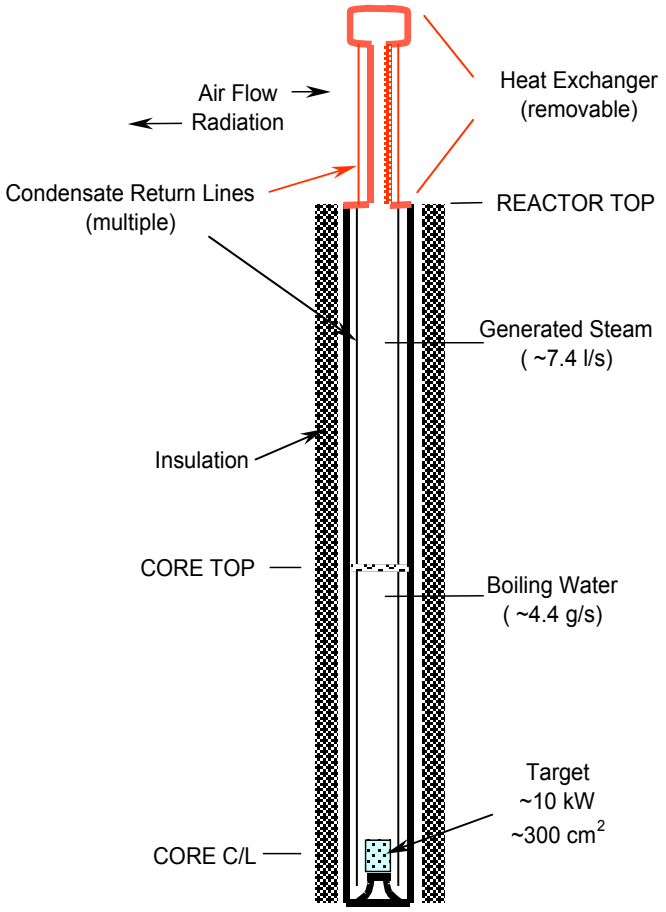
TREACS Target





Target assembly - cooling





Sodium-Cooled ADS Reference Design

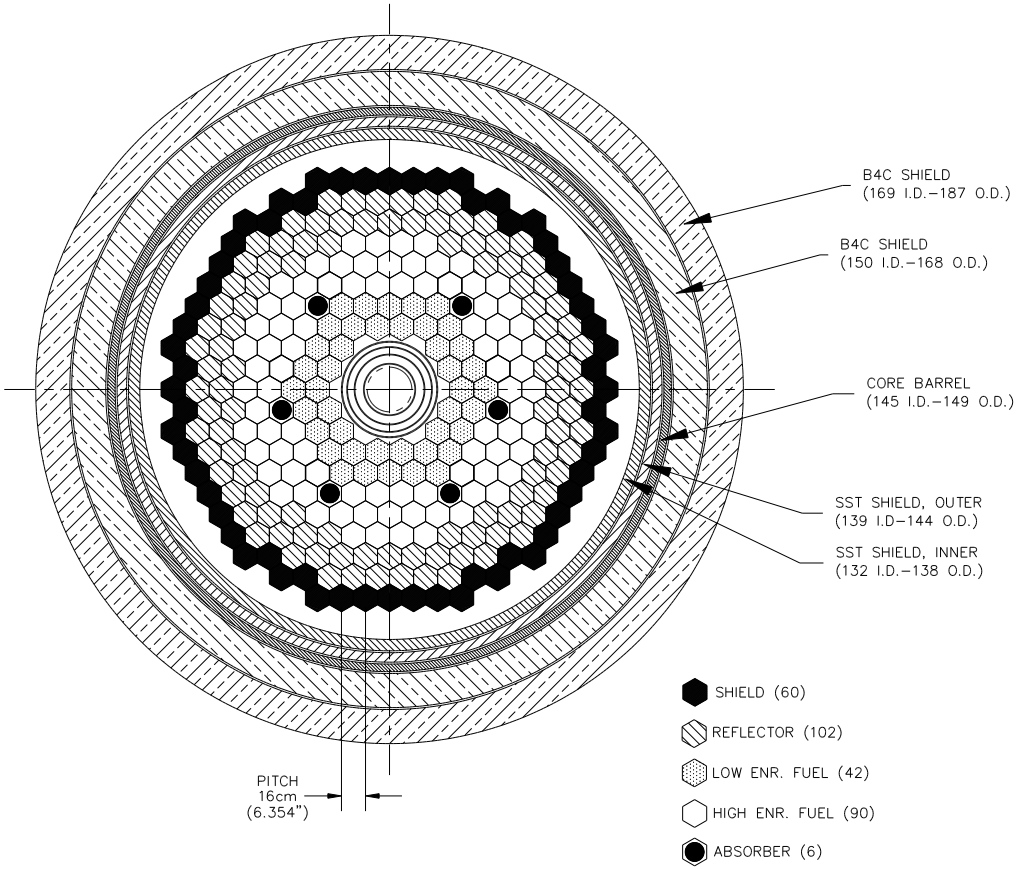
- Basic approach
  - Scale-up of ADTF (100 MW_{th}) to full size (~800 MW_{th})
  - Engineering solutions to resolve scaling problems
  - LBE target: scale-up of ADTF counterpart
  - Use of existing core point design
- Assume use of energy (e.g., maintain capability for electricity production)
- Develop functional and design requirements for feedback to update ADTF requirements

Engineering Design of Reference ADS

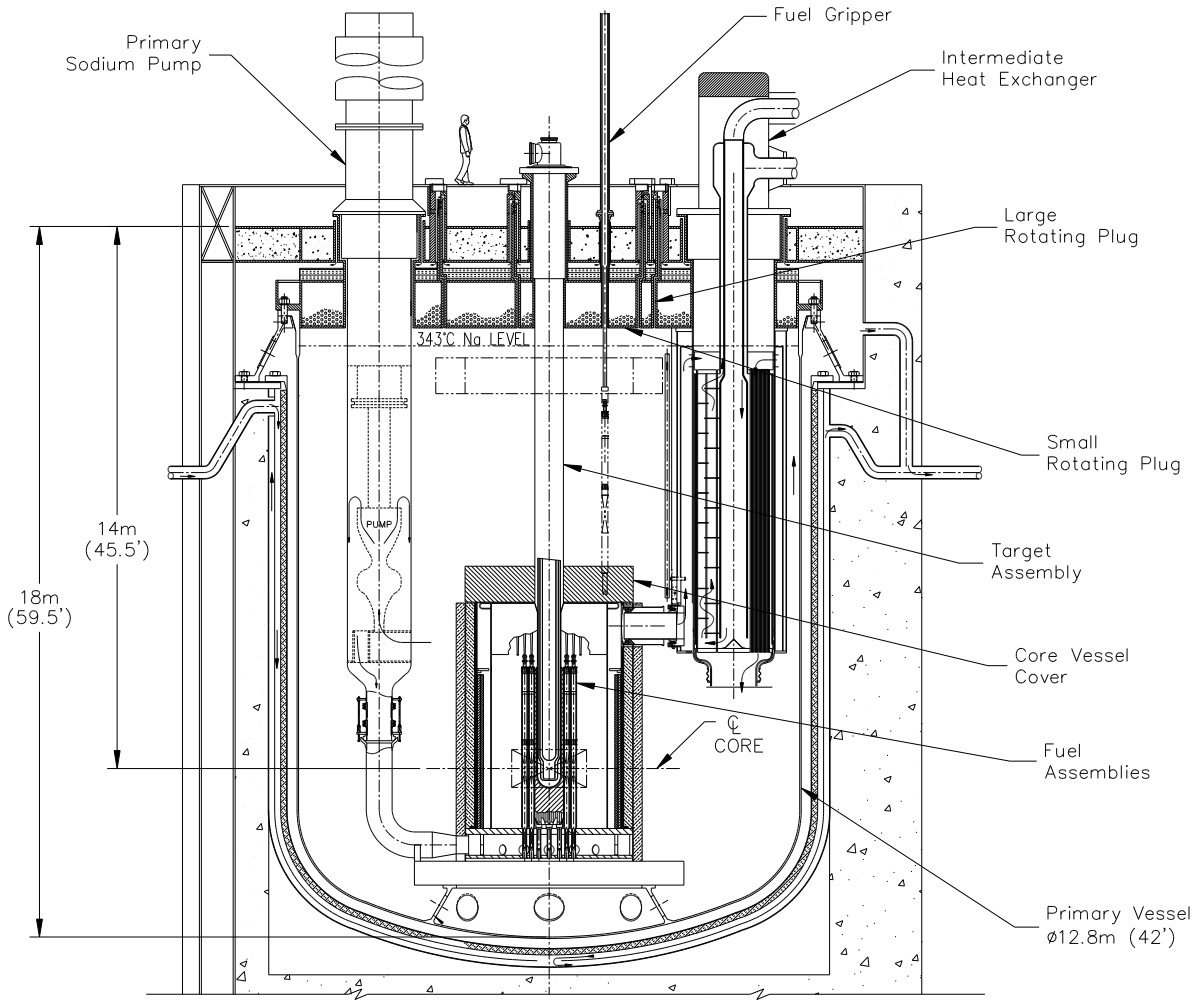
- Primary systems design
  - Use existing sodium system core point design (~840 MW_{th}) from LA-UR-01-1817
  - BNL developing core models with more realistic target geometry and dimensions
  - Scaled-up primary tank and main components
  - Arranged equipment on top of primary tank cover to allow for refueling and re-targeting operations
  - No modified design available for ADS High-Energy Beam Transport (HEBT) or In-Pile Beam Tube (IPBT) - ADTF designs scaled up geometrically
  - Control system

CORE - Point Design

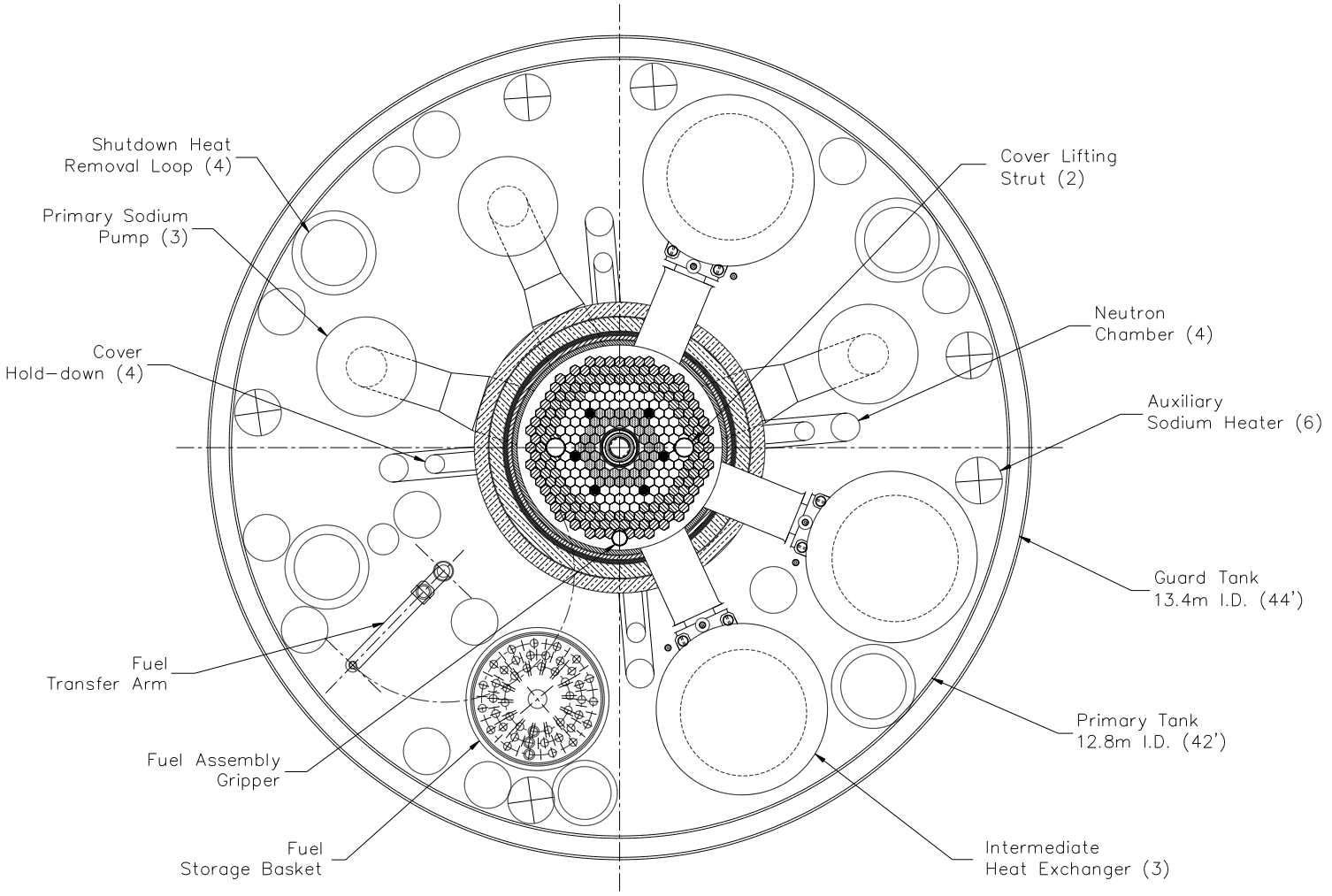
- Thermal power: 840 MW_{th}
- Initial k_{eff}: 0.97 - 0.98
- Coolant inlet temperature: 343ºC
- Temperature rise: 167ºC
- Active fuel: 96.5-cm-long
- Optional Absorber assemblies



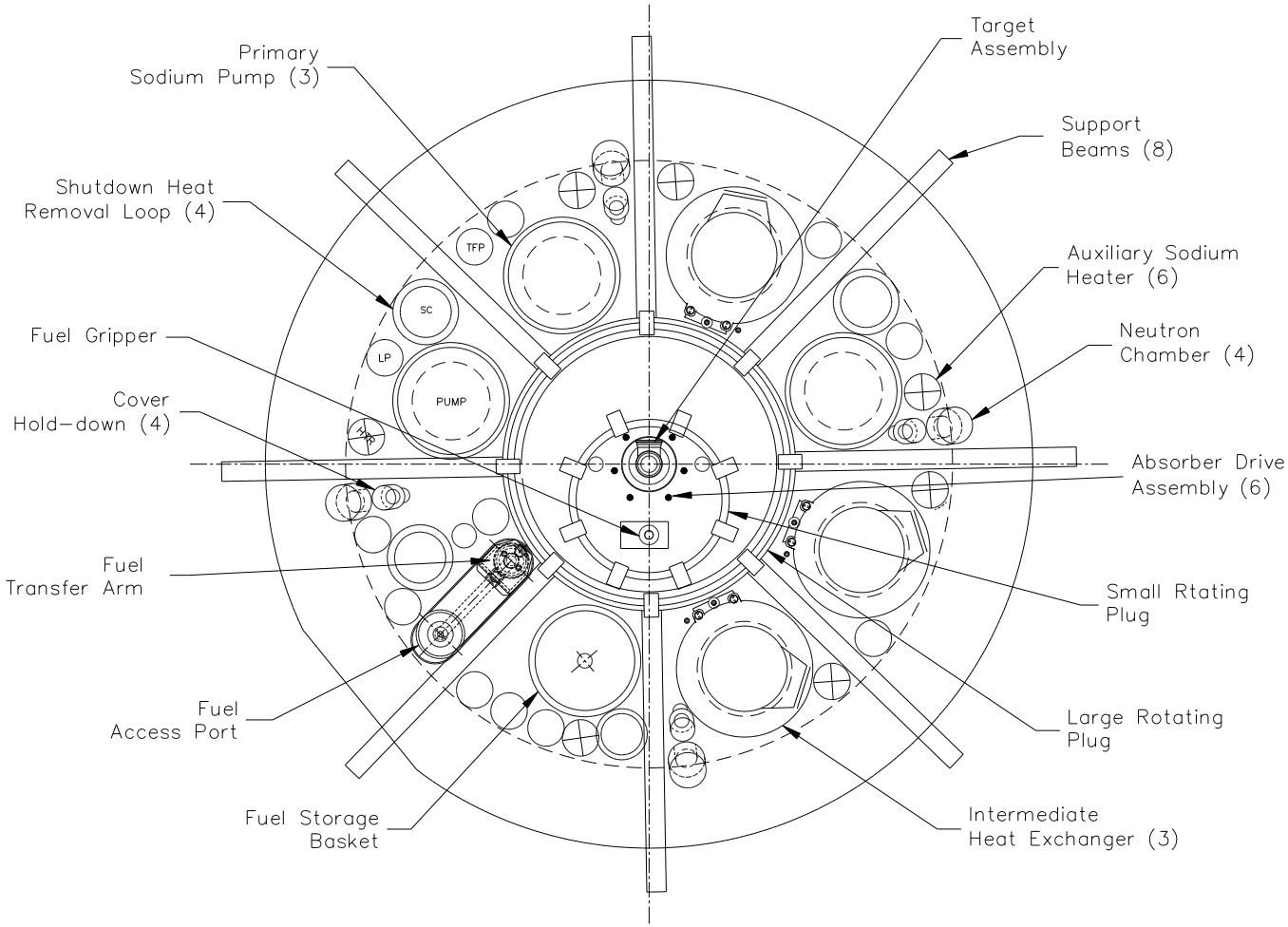
ADS Reference Design - Elevation View



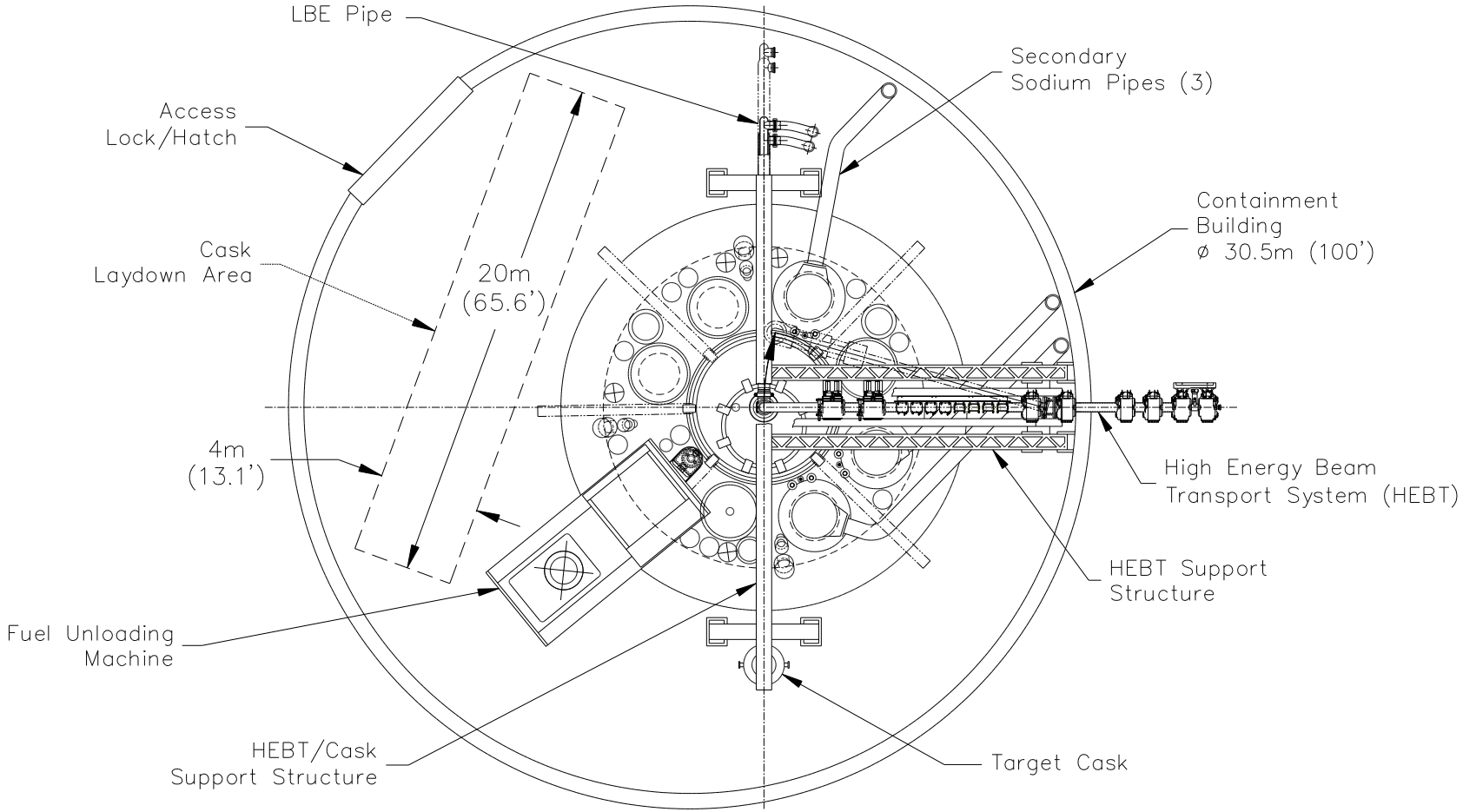
Plan View of Primary Tank



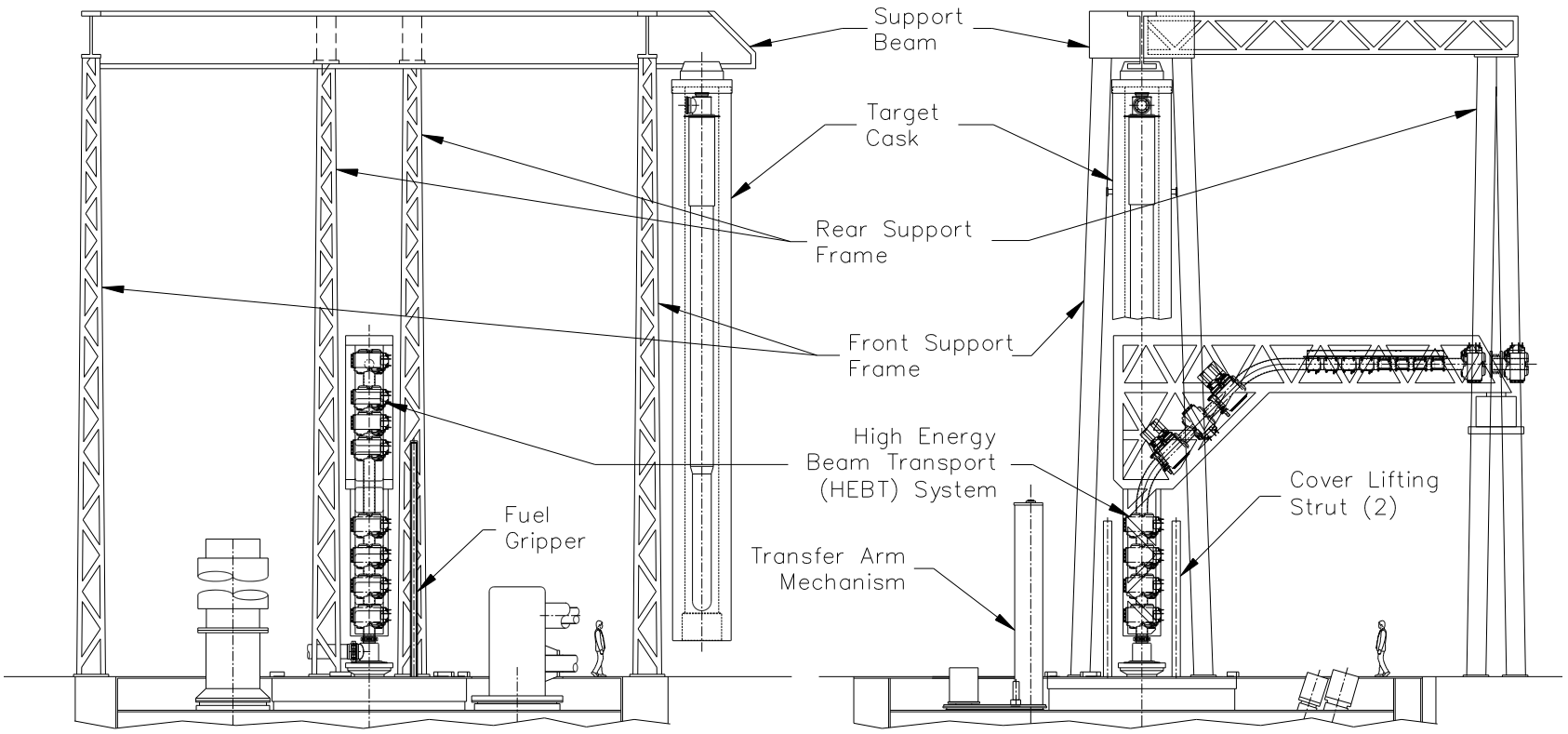
Plan View of Primary Tank Cover



Plan View of Operating Floor



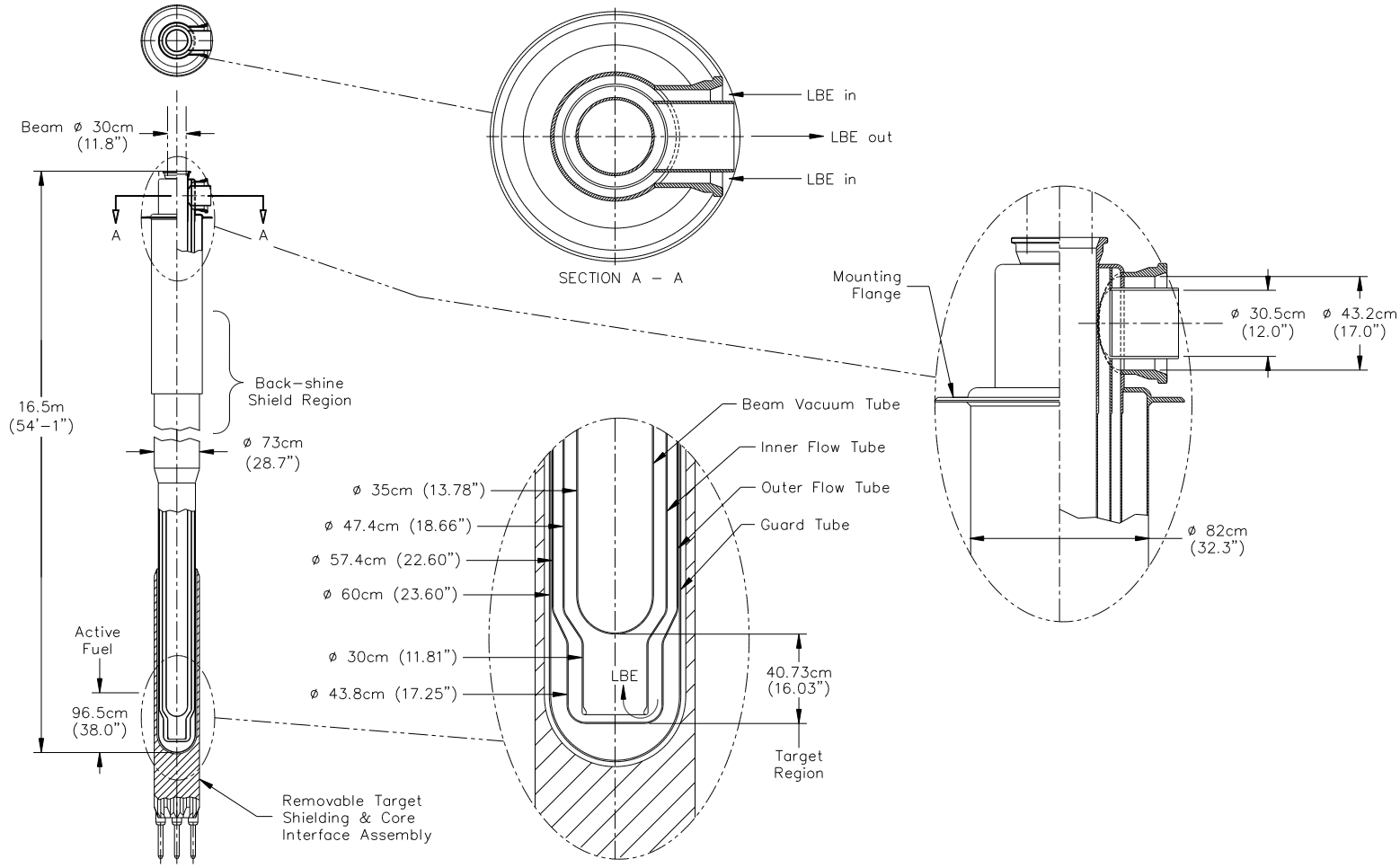
HEBT Support Structure



ADS LBE Target

Feature	ADS Target	SCM Power (MW^{th})	1008	40	SCM fuel zone dia

ADS LBE Target



ADS Target

- Difficulties in direct scaling up of the LBE target
  - Size of inlet/outlet piping
  - Mass of LBE in target assembly (including LBE in circulation)
- Possible alternative LBE target designs that do not require external cooling
  - Helical pipes cooled with multiplier sodium
  - Target with multiple layers of spheres cooled with multiplier sodium.
    - Currently assessing effect of basic design parameters (diameter of spheres, number of layers)

ADS Requirements

- Functional and design requirements cannot be adapted simply from requirements developed for ADTF
  - ADTF was a test facility
  - Effects of size on beam and control requirements
  - ADTF assumed initial operation with EBR-II fuel
- Requirements need to be developed:
  - Based on facility mission
  - Optimization process for main design parameters
  - Include constraints: safety, desired fuel composition

ADS Requirements (cont'd)

- A preliminary set of functional and design requirements has been issued
  - Main parameters for optimization are identified
    - Fuel type
    - Operational cycle
    - Initial k_{eff} and burnup swing
    - Control approach: trade-off between control by beam current adjustment and reactivity compensation devices (i.e., absorber assemblies with no scram function)
  - Integrate process in
    - Facility engineering design
    - Safety case for ADS

Plans for Remainder of FY '02

- Complete report on engineering feasibility of TREACS
- Complete report on preliminary sodium-cooled ADS reference design (ADTF-based)
- Explore alternative target designs
- Further develop the approach optimization of the design requirements
- Feedback requirements for an update of ADTF functional requirements